The Prototype SMOS Soil Moisture algorithm

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Abstract

The SMOS mission will provide for the first soil moisture and ocean salinity at the global scale. The principle for soil moisture monitoring is the high sensitivity of L-band measurements to surface soil water content (typically 0 - 3 cm deep).

Over land areas, SMOS will provide global surface soil moisture maps every 3 days and vegetation water content every 10 days.

Temporal analysis of the basic data and merging with remote sensing databases and models will allow estimating different hydrological variables.

In this way, daily global maps of soil moisture at the reference spatial resolution, as well as more sophisticated products will be provided: rainfall, high resolution soil moisture, root zone soil moisture, flooding, water bodies, fire risk index maps using different approaches and auxiliary data as well as in synergy with other sensors

LEVEL 2 : Soil Moisture swath-based maps

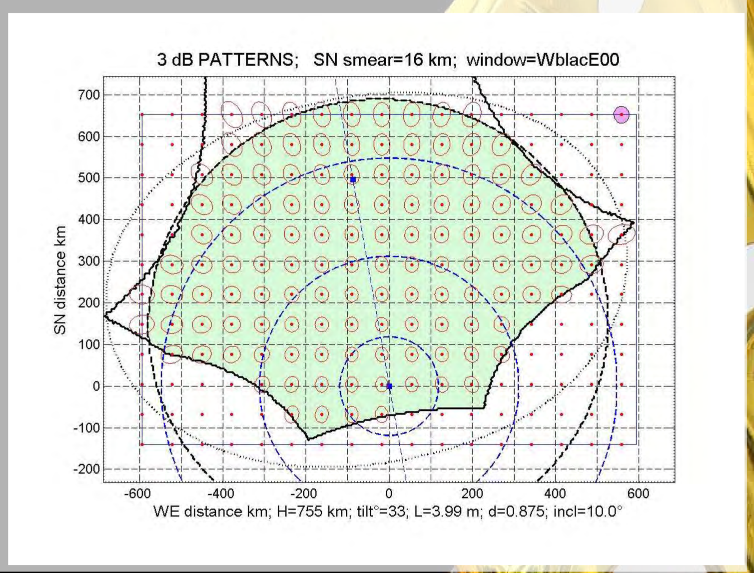
spatial resolution : isea grid 15 km

temporal repetitivity 3 days

accuracy 0.04 m^3m^{-3}

Other geophysical parameters derived when possible (vegetation opacity, surface temperature ...)

- Each integration time, (2.4 s) a full scene is acquired (dual or full pol)
- Average resolution 43 km, global coverage
- A given point of the surface is thus seen with several angles
- Maximum time (equator) between two acquisitions 3 days

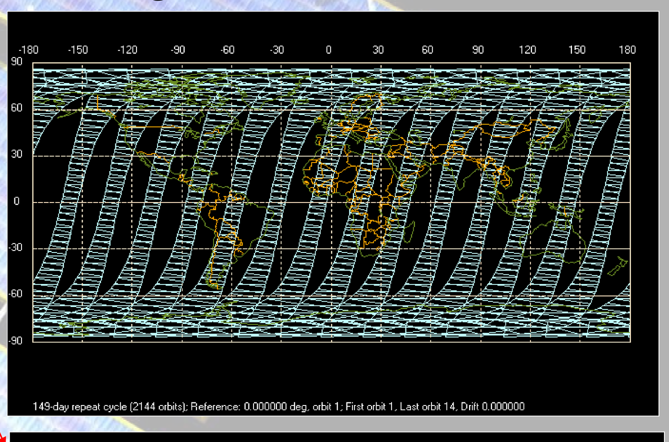


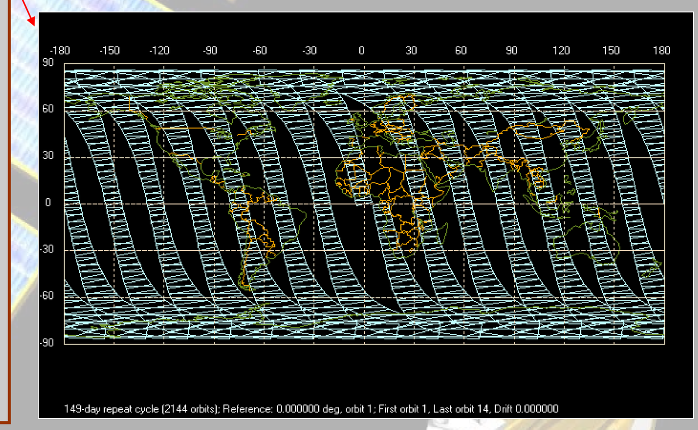
SMOS one day surface coverage

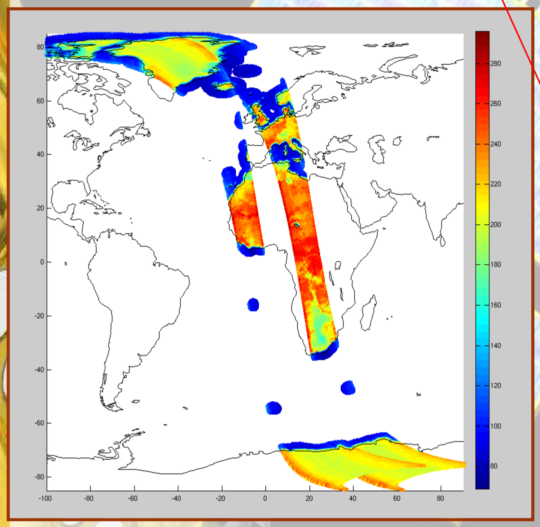
entire Earth covered in 3 days

Ascending orbit

Descending orbit

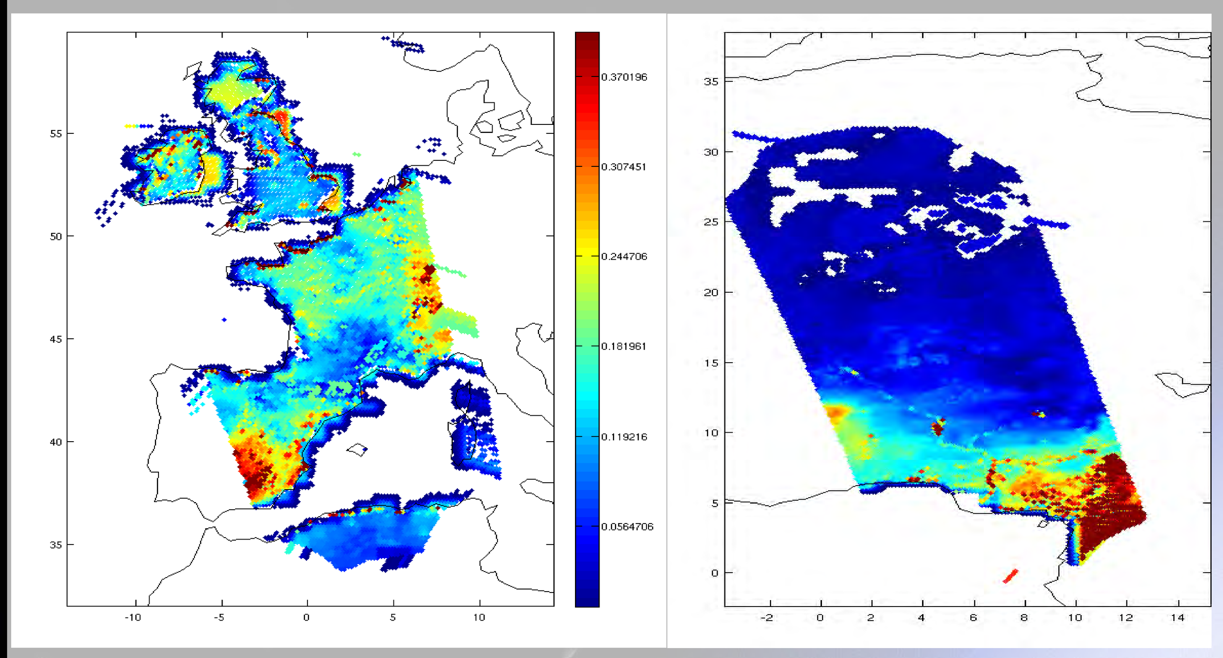






Soil Moisture L2 products :

First results from model simulations over Europe and Africa



LEVEL 2 : Rationale and approach

To be ready at launch → no statistical approaches at the onset

- Focussed on most common land surfaces with room for extension → has to work!
- Physically based on validated models
- Modular and upgradable as research progresses and data is available / analysed
- Relatively complex and to be simplified according to actual measurements
- Use of external data
- We are bound to discover a few things

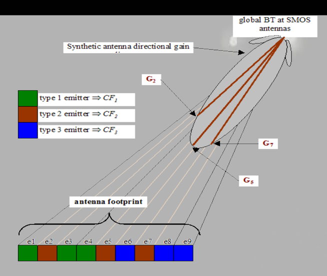
For each **SMOS** grid location, a vector of TB_{SMOS} is provided for a list of incidence angles θm;

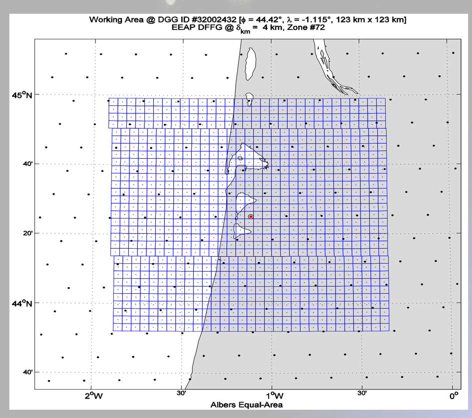
Then the retrieval algorithm minimizes a **cost function** C:

$$C = (\Delta TBM_m)^t \left[COV\right]^{-1} (\Delta TBM_m) + \sum_i \frac{[p_i - p_{i0}]^2}{\sigma_i^2}$$

: Aggregated fractions FM_0 and FM

FM0 class	Aggregated land cover	FM class	Complementarity	
A	B	C	D	E
FNO	Vegetated soil + sand	FNO	Comple-mentary	Sum of comple-mentary fractions equals unity
FFO	Forest	FFO		
FWL	Wetlands	FWL		
	Open fresh water	FWP		
	Open saline water	FWS		
FWO	Open water			
FEB	Barren	FEB		
FTI	Total Ice fraction			
	Ice & permanent snow	FEI		
	Sea Ice	FSI		
FUL	Low urban coverage			
FUM	Moderate urban coverage			
FTS	Strong topography		Supple-mentary	Supple-mentary fractions are super-imposed
FTM	Moderate topography			
FRZ	Frost	FRZ		
FSN	Non permanent dry snow	FSN		
	Non permanent wet snow			
	Non permanent mixed snow			





1st stage of decision tree

The 1irst stage addresses selection of fraction for retrieval and model for retrieval.

- scene fraction covered by vegetated soil or forest large enough:
  SM is retrieved
  radiative contributions from other fractions are computed using ancillary data.
- another cover is prevailing:
  dielectric constant information is retrieved on this fraction using the "cardioid" formulation (with water as a particular case)
  radiative contributions from other fractions are computed using ancillary data.
- The scene is highly homogeneous:
  Dielectric constant equivalent information is retrieved.

  Topography is flagged.

Up to **18 ranked branches** are provided for, depending on scene composition.

2nd stage of decision tree

The second stage of decision tree addresses the selection of additional parameters to be retrieved, and associated a priori constraints (while initial values are obtained from auxiliary information).

Retrieval potential for SM depends mainly on:

- Incidence angle coverage ; decreases as swath abscissa increases away from track and spurious data are removed
- Equivalent vegetation nadir optical thickness τ

%

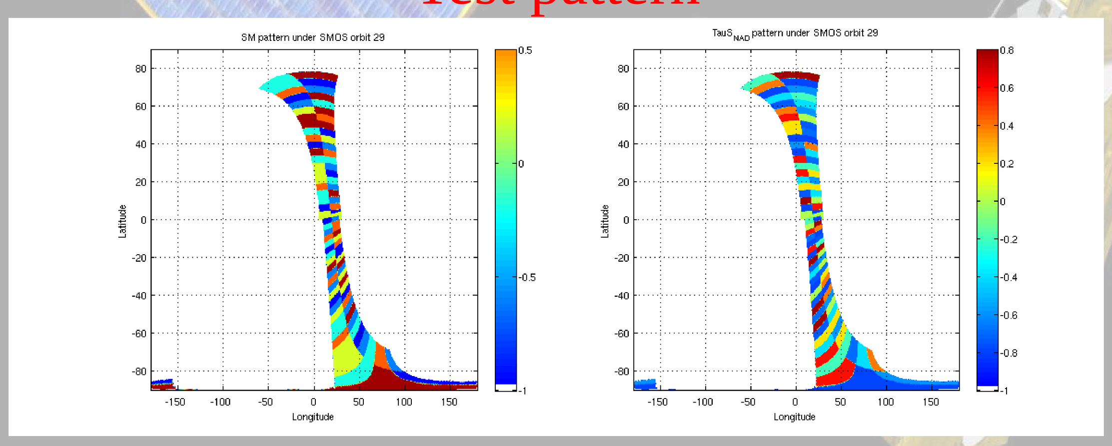
9 branches are defined (3 for θ coverage, 3 for τ initial value)

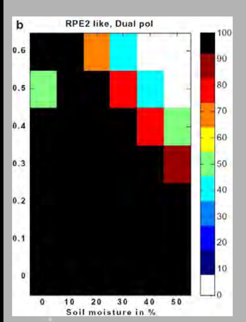
SM and τ are always retrieved. Selected additional parameters are

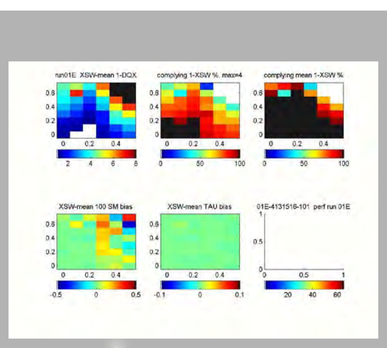
- vegetation albedo and coefficient for variation of optical thickness with θ.
- Coefficient in soil roughness modelling (although the retrieval potential is weak).

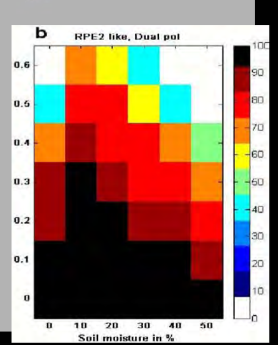
Vali-veri-da-fica-tion

Test pattern

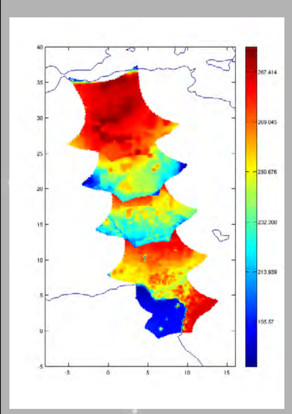


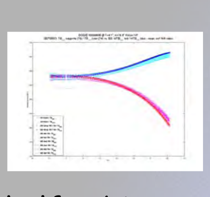






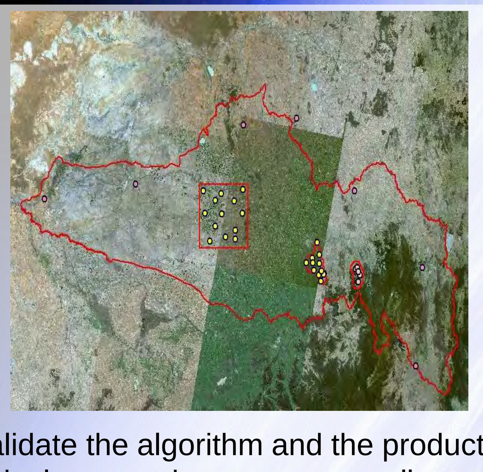
Results – L1c





All snapshots for 3 half orbits

Extensive periods for reduced areas of interest



Need to validate the algorithm and the products:

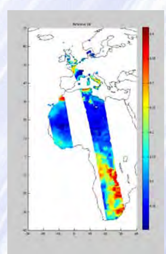
A) Theoretical scenes, homogeneous, all over the swath, exact data acquisition, typical noise figure, exact geometry

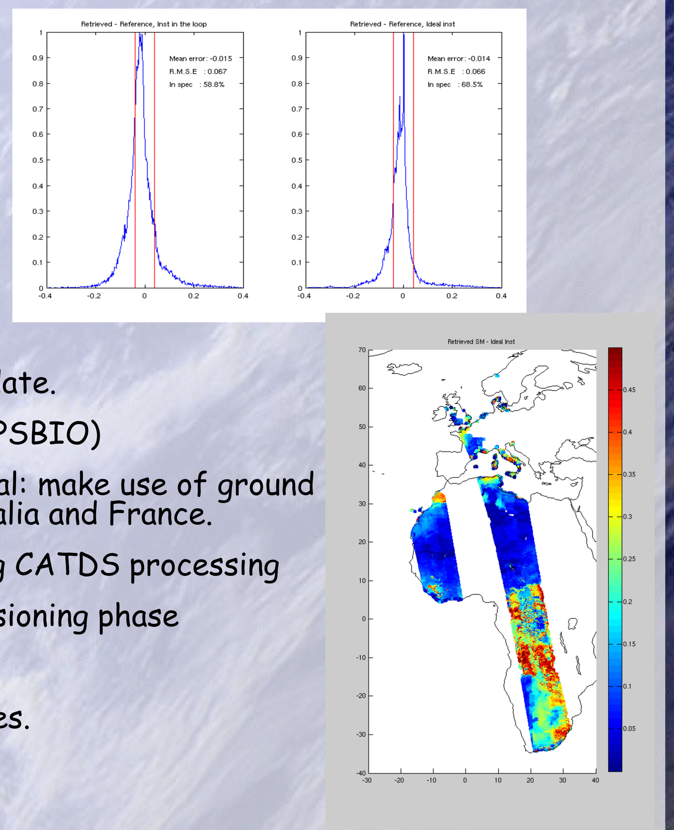
B) Step in SM and vegetation opacity over the whole range

C) Same analysis on realistic synthetic data sets Global and high resolution
15 days at several dates (solstices and equinox)

D) Validation on ground data sets and then real sat data during commissioning phase

Results – L2SM





Keep simulators and prototype up to date.

Finalise and fully test End to end (SEPSBIO)

Participate in commissionning rehearsal: make use of ground campaign in Germany, Spain, Australia and France.

Take simulation to level 3, prototyping CATDS processing

Fully validate/ correct during commissioning phase

Feed back to level 1

Start working on statistical approaches.

CONCLUSION :

SMOS will be the first mission to deliver global fields of soil moisture and sea surface salinity

It is an EXPLORER Mission ==> new concept new instrument new measurements: The challenge → **NO data exists, NO algorithm validated with real exists: we are breaking new grounds**

Requires extrapolation from higher frequency results and/or local ground measurements → Level 2 algorithms are designed to be improved as knowledge progresses

After Some time for data acquisition with a reasonable range of conditions (1 year minimum)→ Statistical approaches and NN will be tested for possible implementation

see documents and more informations : http://www.cesbio.ups-tlse.fr/fr/indexsmos.html